

# **INDOOR AIR QUALITY ASSESSMENT**

**Zervas Elementary School  
30 Beethoven Avenue  
Newton, Massachusetts**



Prepared by:  
Massachusetts Department of Public Health  
Bureau of Environmental Health Assessment  
Emergency Response/Indoor Air Quality Program  
September 2003

## **Background/Introduction**

At the request of the Newton Health Department (NHD), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Zervas Elementary School, 30 Beethoven Avenue, Newton, Massachusetts.

On March 20, 2003, a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, an Environmental Analyst in the Emergency Response/Indoor Air Quality (ER/IAQ) program, BEHA. Robert DeLuca, Senior Inspector, Newton Health Department; David Murphy, Senior Custodian; Lucinda Avlonitis, Principal and a number of teachers and parents who are members of the Zervas Health and Safety Committee, accompanied Mr. Holmes for portions of the assessment.

The school is a one-story brick building constructed in the early 1950's. A modular classroom (reportedly added approximately five years ago) serves as the school library. The school contains general classrooms, gymnasium, library, health suite and main office. The former auditorium/stage area has been renovated and converted into classroom space.

According to school and health officials, the school has a history of water damage and indoor air quality issues. In response to these issues, the school has taken measures over the last several years to improve conditions in the building. A number of these measures are listed below as reported by health and school officials. These measures include:

- Forming a health and safety committee involving parents, school staff, maintenance personnel, town health officials as well as instituting the Environmental Protection Agency (EPA), Tools for Schools program.

- Replacing all carpeting in classrooms with either tile or a combination of carpeting and linoleum (3/4 carpet to 1/4 tile);
- Removing all water damaged porous items from the crawlspace;
- Remediating mold contaminated materials;
- Repairing plumbing/steam leaks;
- Installing a vapor barrier on the crawlspace floor (Picture 1);
- Installing exterior bulkheads so interior access plates could be sealed;
- Installing a hard ducted mechanical exhaust ventilation system to depressurize the crawlspace (Pictures 2-4);
- Restoring unit ventilators and rooftop exhaust to working order;
- Replacing Venetian blinds in classrooms with shades to reduce dust accumulation;
- Thorough cleaning and disinfection of classroom interiors including complete removal of wall mounted book shelves so radiator fins could be cleaned as well as the interior of unit ventilator cabinets; and finally
- A log/notebook is kept in the main office for school staff to document complaints or concerns.

## **Methods**

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

## **Results**

This school houses approximately 300 in grades K-5 and has a staff of approximately 60. Tests were taken during normal operations at the school. Results appear in Table 1.

## **Discussion**

### **Ventilation**

It can be seen from the tables that carbon dioxide levels were below 800 parts per million of air (ppm) in twenty of twenty-six areas surveyed, indicating adequate air exchange in most areas of the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 5) and returns air through an air intake located at the base of each unit ([Figure 1](#)). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. All univents were operating during the assessment. Obstructions to airflow, such as furniture configured around univents, were seen in several classrooms (Picture 6). In order for univents to provide fresh air as designed, intakes and return vents must remain free of obstructions.

Exhaust ventilation is provided by a mechanical system, which draws air into an ungrated hole located at floor level in classrooms (Picture 7). Airflow is controlled by a flue located inside the duct. Exhaust vents were operating in most of the classrooms surveyed. No draw was detected in the music room and room 1L-3, which can indicate that the system was deactivated or not operable. BEHA staff examined conditions on the roof and found that the belt to exhaust motor L-3 was loose. Items were also seen obstructed a number of exhaust vents in classrooms

(Picture 8). As with the univents, exhaust vents must remain free of obstructions to function as designed.

Exhaust ventilation in the gym is provided by a wall mounted-grill that was blocked by exercise mats (Picture 9). This system was deactivated during the assessment. In order to function as designed, exhaust ventilation must remain activated. Restrooms are equipped with ceiling and/or wall-mounted exhaust vents. The exhaust vent in the boy's room near the Principal's office appeared to be "blowing" air instead of "drawing".

The library is located in a wing of modular classrooms. Mechanical ventilation for the library is provided by rooftop air handling units (AHUs). Fresh air is distributed to classrooms via ductwork connected to ceiling-mounted air diffusers. Return vents draw air back to the units through wall or ceiling-mounted grilles. Thermostats control each heating, ventilating and air conditioning (HVAC) system. Thermostats have fan settings of "on" and "automatic". Thermostats were set to the "automatic" setting during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once a preset temperature is measured by the thermostat, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. It is recommended that the fan be set to the "on" mode to allow for the provision of fresh air.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. According to school department officials, the date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or that each room have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see [Appendix I](#).

Temperature readings ranged from 67 ° F to 76 ° F, which were below the BEHA comfort guidelines in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many

cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Excessive heat complaints were expressed in Room 10. This room is located in the former auditorium. Conversion of the auditorium into a classroom occurred without modifications to reduce heat provided by the original auditorium ventilation system. Due to the difference in ventilation requirements between an auditorium and classroom (e.g. size, occupancy), room 10 receives an excessive amount of heated air.

The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 19 to 25 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### **Microbial/Moisture Concerns**

A dark patch, which may have been mold growth, was observed on pipe insulation wrap in the crawlspace. No obvious interior sources of water leaks were observed. The most likely source of moisture is condensation. The pipe insulation may be composed of an asbestos containing material. The section of pipe insulation should be remediated in conformance with all applicable Massachusetts asbestos abatement and hazardous materials disposal laws.

Caulking around windows was missing/damaged in many areas (Pictures 10 & 11). Missing caulking and/or loose fitting windowpanes can create difficulties in temperature control

(e.g. drafts). Furthermore, spaces around window panes/frames can allow for water penetration, which can lead to water damage and subsequent mold growth.

Efflorescence (i.e. mineral deposits) was observed on windowsills (Picture 12).

Efflorescence is a characteristic sign of water damage to building materials such as brick or plaster, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, water evaporates, leaving behind white, powdery mineral deposits. This condition indicates that water from the exterior has penetrated into the building. In this case the most likely source of water penetration is around window frames.

Spaces between the sink countertop and backsplash were noted in some classrooms (Picture 13). Improper drainage or sink overflow could lead to water penetration of countertop wood, the cabinet interior and behind cabinets. If porous materials become wet repeatedly they can provide a medium for mold growth.

Water coolers in the teachers' room were installed over carpeting. Spills from water coolers can result in wetting of the carpet, which can lead to mold growth especially if wetted repeatedly. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Mold colonized carpeting cannot be adequately cleaned to remove microbial growth.

Shrubby and other plants exist in close proximity to exterior walls. The growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can

undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

### **Other Concerns**

Several other conditions that can affect indoor air quality were noted during the assessment. Of note was the amount of materials stored inside classrooms. In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g. papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. For this reason, items should be relocated and/or cleaned periodically to avoid excessive dust build up. A univent was opened to inspect the interior and had accumulated dust and cobwebs. The operation of univent fan motors can aerosolize dust particles. In addition, these materials can accumulate on flat surfaces in occupied areas and subsequently be re-aerosolized causing further irritation.

A strong chemical odor was detected in the kitchen/cafeteria hallway. A number of air fresheners were observed, including the plug-in type. Cleaning products were found on countertops and beneath sinks in a number of classrooms (Picture 11). Cleaning products and air fresheners contain chemicals, which can be irritating to the eyes, nose and throat. Air fresheners do not remove materials causing odors, but rather mask odors, which may be present in the area.

The interiors of several univents were examined. Spaces around heating pipes were observed (Picture 14). Spaces of this nature can result in the univent drawing air and debris from the crawl space and distributing these materials to the interior of the building.

A few classrooms contained assorted animals in cages. Porous materials (i.e. wood shavings) can absorb animal wastes and can be a reservoir for mold and bacterial growth. Animal dander, fur and wastes can all be sources of respiratory irritants. Animals and animal cages should be cleaned regularly to avoid the aerosolization of allergenic materials and/or odors (NIOSH, 1998).

Finally, several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

## **Conclusions/Recommendations**

In view of the findings at the time of the inspection, the following recommendations are made:

1. Remediate section of pipe in crawlspace in conformance with all applicable Massachusetts asbestos abatement and hazardous materials disposal laws.
2. Remove all blockages from univents and exhaust vents. Clean out interiors of univents regularly (e.g. with filter changes).
3. Operate both supply and exhaust ventilation continuously during periods of school occupancy, independent of classroom thermostat control.
4. Inspect rooftop exhaust motors and belts for proper function. Repair and replace as necessary.
5. Examine exhaust vent in boy's restroom near the Principal's office for proper function. Repair and replace as necessary.

6. Consider setting thermostat controls in modular classrooms (library) to the “on” position to provide constant supply and exhaust ventilation during periods of occupancy.
7. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.
8. The ventilation engineer should also provide advice concerning modification to the former auditorium ventilation system in classroom 10 to reduce heat.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
10. Repair/replace loose/broken windowpanes and missing or damaged window caulking building-wide to prevent water penetration through window frames. During this project it is recommended that all water-damaged materials be examined for microbial growth and structural integrity. Repair water damaged ceilings, walls and wall-plaster as necessary.
11. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Disinfect areas of microbial growth with an appropriate antimicrobial as needed. Consider replacing with one-piece, molded countertops.
12. Seal wall and pipe floor holes within univent casing.
13. Store cleaning products properly and out of reach of students.

14. Refrain from using strong-scented materials (e.g. air fresheners).
15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
16. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at <http://www.state.ma.us/dph/beh/iaq/iaqhome.htm>.

## References

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SMACNA. 1994. HVAC Systems Commissioning Manual. 1<sup>st</sup> ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

**Picture 1**



**Plastic Polyethylene Vapor Barrier Installed in Crawlspace**

**Picture 2**



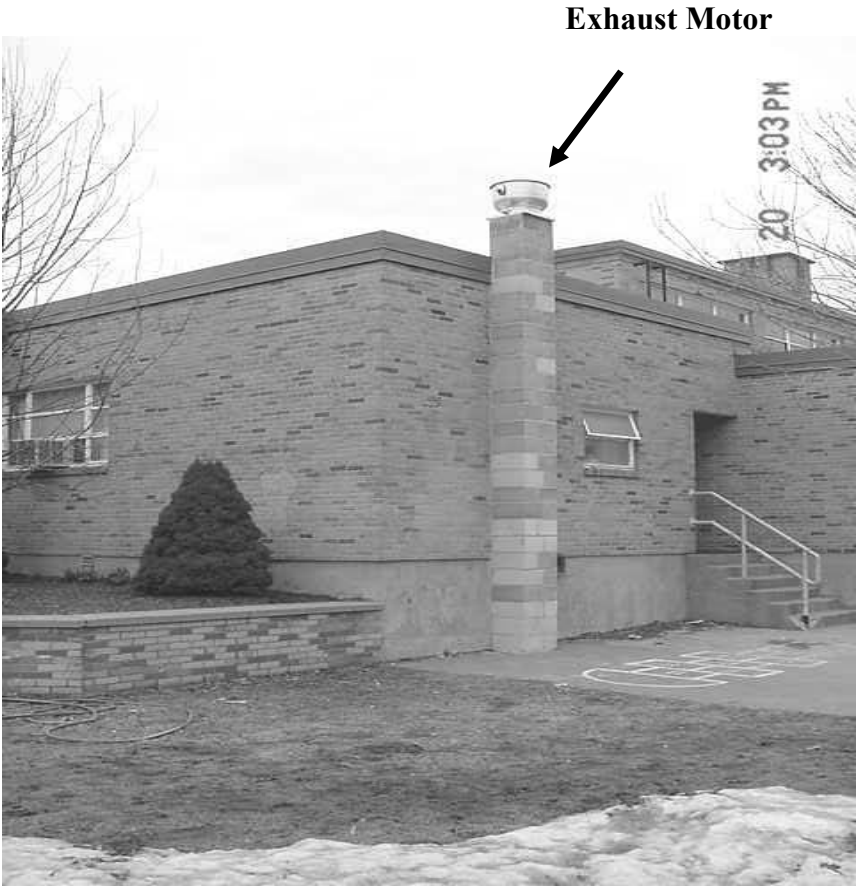
**Bulkhead Installed for Crawlspace Access**

**Picture 3**



**Passive Crawlspace Vent (Make-Up Air)**

**Picture 4**



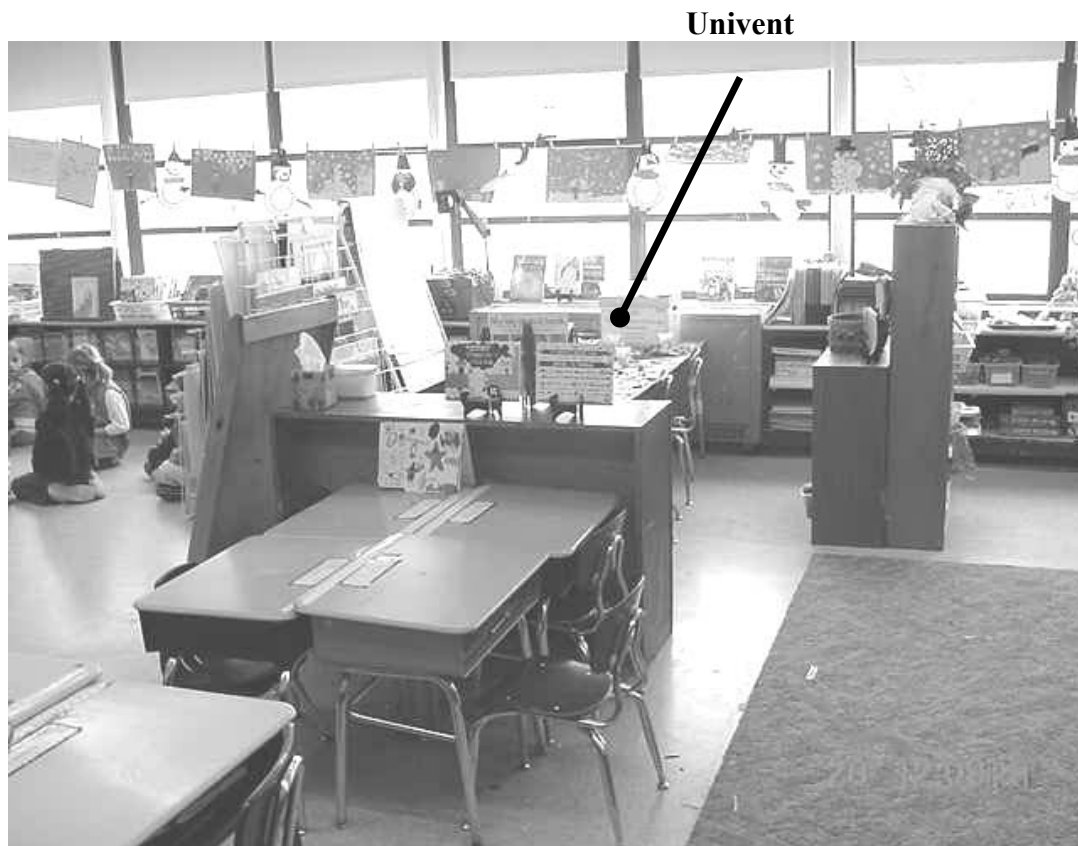
**Mechanical Crawlspace Exhaust Vent/Chimney**

**Picture 5**



**Univent Fresh Air Intake, Note Close Proximity of Foliage**

**Picture 6**



**Classroom Furniture Configured around Univent Obstructing Airflow**

**Picture 7**



**Exhaust Vent/Ungrated Hole**

**Picture 8**



**Exhaust Vent/Ungrated Hole Used for Classroom Storage**

**Picture 9**



**Exercise Mats Obstructing Exhaust Vent**

**Picture 10**



**Peeling/Damaged Caulking, Interior of Window**

**Picture 11**



**Missing/Damaged Caulking on Exterior of Window**

**Picture 12**



**Efflorescence (Mineral Deposits) on Interior of Window**

**Picture 13**



**Peeling Countertop of Classroom Sink**

**Picture 14**



**Spaces around Utility Pipes in Univent Casing**

**TABLE 1****Indoor Air Test Results –Zervas Elementary School - Newton MA****March 20, 2003**

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outdoors (Background)	398	51	24					Clear sunshine NW winds 10 – 15 mph
Room 15	672	73	24	21	Y	Y	Y	Cleaning product on/under sink, door open
Room 14	838	73	22	15	Y	Y	Y	
Room 16	673	73	20	1	Y	Y	Y	16 occupants gone 15 min. cleaners on counter
Room 13	775	72	21	15	Y	Y	Y	
Teachers Room	692	71	25	2	N	N	Y	Space behind sink, Window AC preventing window from opening, water cooler on carpet
Room 12	606	71	20	18	Y	Y	Y	Plants Items on UV
Room 11	565	73	20	1	Y	Y	Y	Spaces - countertop
Gym	891	77	21	20	Y	Y	Y	Exhaust vent not operating- blocked by mats
After School Room 1	781	74	20	2	Y	Y	N	

\* ppm = parts per million parts of air  
 UV = Univent

**Comfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred  
 600 - 800 ppm = acceptable  
 > 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

**TABLE 1****Indoor Air Test Results –Zervas Elementary School - Newton MA****March 20, 2003**

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Room 21-A	621	75	19	0	N	N	Y	
After School Room 2	623	75	19	0	Y	Y	Y	
Room 10	577	77	21	16	Y	Y	Y	Health/temperature complaints
Room 9	778	74	20	24	Y	Y	Y	UV installed
Music Room	601	74	19	2	Y	Y	Y	Exhaust and supply off
Nurses Office	650	74	21	0	Y	Y	Y	Passive vent
Room 7	853	73	21	19	Y	Y	Y	Broken window, plants
Room 6	733	72	21	17	Y	Y	Y	Items on UV, plants, cleaning product on tray and under sink
Room 5	708	74	22	24	Y	Y	Y	Exhaust partly blocked, door open, cleaning products under sink
Room 4	924	75	21	18	Y	Y	Y	Plants near UV diffuser, heat issues, thermostat set at 64 °F actual temperature 76 °F

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						Supply	Exhaust	
Room 3	806	75	20	24	Y	Y	Y	Plants
Room 2	975	73	21	22	Y	Y	Y	Exhaust blocked, plants UV partially blocked
Room 1L-3	735	72	22	18	Y	Y	Y	Exhaust vent - no draw
Room L-2	718	68	24	6	Y	N	Y	10 occupants gone 5 min. exhaust vent in room L-3 separated by wall
Room L-1	549	70	24	0	Y	Y	Y	Modular unit. fan “Auto” set to “on” position
Main Office	632	71	22	1	N	Y	Y	Thermostat “Auto”
Principal Office	627	73	21	1	Y	Y	Y	
Boys Room				--	Y	Y	Y	Exhaust vent blowing
Girls Room				--	Y	Y	N	
Teachers Office								Plants in water
Rooftop								Loose belt Exhaust motor (L-3)

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						Supply	Exhaust	
Crawl Space								Vapor barrier, no visible standing water/water damage, pipe insulation – dark stain (mold)
Kitchen off Hallway								Strong air freshener/chemical odors

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